3.0 SUMMARY OF ASSUMPTIONS, LIMITATIONS AND ERRORS

This section of ASP-I summarizes assumptions, limitations, and known errors of the model. This information is useful in helping a user to determine if the model adequately addresses all the phenomena and environmental conditions that are important to the intended application. These assumptions, limitations, and errors are derived from any and all applicable sources (including model documentation and especially V&V reports), and addresses the implications of these for model use or application. These assumptions, limitations, and errors are derived from any and all applicable sources. Table 3-1 lists overall model limitations. Detailed assumptions and limitations are listed in Table 3-2, where they are indexed by functional element. Table 3-3 lists known errors at the time that version V6.2 was released.

TABLE 3-1. Brawler Model Level Limitations.

Limitation	Impact Assessment
Brawler simulates perfect correlation between successive observations. A sensor observation of object X will always cause an update of an existing track containing object X. A new track will never be generated if a track on that object already exists, even if the new observation state is far from the track state.	Effects due to mis-correlation, false tracks not explicitly addressed.
Brawler output is not formatted for input directly into theater or campaign level models.	Requires users to manually reformat data or to build their own formatting tools.
Brawler V6.2 has a DIS based interface that allows it to run in confederation with EADSIM, but is not DIS compliant.	Restricts usefulness in distributed simulation exercises. *Work to achieve DIS compliance is already under contract and will be available in future versions.*
Brawler V6.2 has no man in the loop (MIL) capability.	Not suitable as a MIL platform, but may be used to generate threats for other MIL stations. *A MIL capability is being developed and will be available in future versions*.
Brawler software is very modular and it exhibits some of the basic object oriented concepts such as encapsulation, polymorphism, and inheritance, but is coded largely in FORTRAN and is not object oriented in the strict definition of the phrase.	No impact on usefulness in studies. Has some implications for cost and level of effort for future maintenance and development efforts.
Brawler is not J-MASS compliant.	No impact on current applications. Implies a future development or replacement cost if J-MASS compliance becomes a requirement.
Brawler does not simulate air-to-surface missions.	Restricts Brawler analysis primarily to air-to-air missions. *Work is currently under contract to provide this capability in future versions.*
Brawler contains only rudimentary surface-to-air (SAM) site models and does not explicitly simulate the detailed command and control structure of an integrated air defense system.	Should not be used to study scenarios where detailed coordination of SAM sites is an important factor.
Typical size of Brawler engagements ranges from 2 to 20 aircraft. More can be run with a runtime penalty.	Restricts range of scenarios that can be studied.

TABLE 3-1. Brawler Model Level Limitations. (Contd.)

Limitation	Impact Assessment
Some Brawler features, such as missile propulsion and aerodynamics, missile endgame, IR signatures, radar cross section, and IFF/NCID devices, can be simulated at more than one level of fidelity. Multiple levels of fidelity are not available across the entire model.	Main impact is on time required to develop input data sets and time required to complete studies.
Brawler does not simulate partially damaged aircraft. Aircraft are either fully functional or destroyed.	Effects of multiple component vulnerability not addressed.
Brawler can simulate multiple layers of clouds that affect both visual and IR detections, but clouds are simulated as opaque layers of finite thickness, extending to infinity. Discrete clouds are not modeled. Cloud motion is not modeled. Precipitation is not modeled.	Effects of localized weather systems not addressed. Effects of dynamic weather not addressed.
Brawler uses time of day to determine night vs. day for use by the visual detection and IR transmissivity models. Position of the sun is not explicitly simulated.	May affect results in studies where long range IR detections are an important factor. *A new format for IR signature calculations is being added which does take the position of the sun into account.*
The IR environment is limited to 5km day, 23km day, 5km night, or 23km night. IR clutter statistics for the surface must be selected from rural, urban, or water for a given engagement.	Restricts studies to these conditions.
Brawler is a Monte Carlo simulation.	Requires multiple runs of each scenario of interest. Has implications for time required to complete a study. *Work is under contract to provide future versions with a deterministic mode that will provide precise control over weapon firing, weapon kill, and sensor and seeker detections in 1v1 engagements.*
National boundaries, FEBA lines, etc., are not simulated.	Restricts model applicability to scenarios where rules of engagement are not defined relative to boundaries. This deficiency can be largely overcome via the production rules facility.
Brawler cannot directly accept as input the output data from other models such as BLUEMAX, ALARM, TRAP, or ESAMS.	Requires users to manually reformat input data or to build their own reformatting tools.
Brawler does not model terrain features.	Restricts usefulness to high enough altitudes that terrain features do not play a significant part. *Work is currently under contract to begin adding this feature to Brawler.*
Brawler pilots always have perfect knowledge of their own location.	Not a significant limitation in most current applications. May have an impact on the simulation of strike missions, where errors in pilot's knowledge of their own positions may affect their ability to correctly identify ground targets. This would be especially true if the identification is to be based on vectoring information supplied by off-board sensors or controllers. One example of this would be correctly identifying the target building in a strike in an urban setting, where a mis-identification could lead to significant collateral damage.

TABLE 3-2. Brawler Assumptions and Limitations, by Functional Element.

Functional Element	Assumption/Limitation	Impact Assessment
III Operator Models	Brawler assumes that simulated pilots will be able to reconsider their decisions frequently enough to react and respond to changes in their environment. Typically, this means reconsideration intervals of less than one second for actively engaged pilots.	Model is not suitable for explicitly simulating activities requiring continuous precise hand-eye coordination, such as gun-firing.
III - 1. Pilot Model	Brawler assumes that the set of alternatives available to a pilot at each level of the decision hierarchy is complete enough to provide a realistic spectrum of responses.	Implies that the range of alternative should be evaluated if significant new capabilities are being simulated.
	When a pilot ceases to detect an aircraft which it has been observing, the projection of the state vector of that aircraft into the future (in the pilot's mind) does not use a strictly constant velocity or constant acceleration model. Instead, the projection is blended with the ground truth state vector of the entity, based on an assumption that a pilot can make some educated guess as to the state vector of an aircraft based upon his knowledge of air combat tactics.	May cause simulated pilots to reacquire threats more quickly than would be the case in the real world. *This feature can be disabled.*
	Since Brawler engagements are initialized with aircraft already aloft, the model assumes that aircraft on the same mission have been aware of one another for some time; thus during the first second of simulation, each pilot is given a "free", high quality observation of all other aircraft on the same mission.	Negligible impact.
IV - 1.3.2.1 Aircraft RF Cross Section	Radar cross section (RCS) is a function of azimuth, elevation, and wavelength. RCS is not a function of polarization.	Model not suitable for studies in which polarization effects are significant.
IV - 1.3.2.3 Visual Signature	Visual detection is a function of pilot visual acuity (an input data element) and target presented area. Aircraft visual cross section is simpler than RCS and is an interpolation between values for nose on, beam, and top visual areas. Detection is subject to the effects of clouds, day vs. night, and cockpit masking angles. Missile visual signature is enhanced when the engine is on. Aircraft signature is enhanced if the aircraft has been destroyed and is falling to the ground.	Only significant if actual aircraft visual cross section differs greatly from the Brawler representation.

TABLE 3-2. Brawler Assumptions and Limitations, by Functional Element. (Contd.)

Functional Element	**Assumption/Limitation**	**Impact Assessment**
IV - 1.2 Aircraft Aerodynamics	Brawler uses a 5-DOF coordinated flight aerodynamics model. It is also capable of simulating post-stall maneuvering and has explicit models of thrust reversers and drag devices. Aircraft center of gravity does not change during an engagement.	Affects results from close-in combat situations where aircraft agility is important. *Thrust vectoring is not simulated, but work is under contract to provide this in future versions.*
IV - 2. Weapons	Each aircraft in a Brawler engagement can carry up to 7 different types of weapons. A maximum of one gun type per aircraft can be carried.	Not able to simulate platforms that exceed these limits. Increasing these limits would not be difficult.
IV - 2.1.1.3 Missile Aerodynamics	The Brawler missile model uses a 4-DOF aerodynamics model. It can accommodate multiple lift and drag tables to simulate aerodynamic changes due to booster or seeker cover separation or differences between the engine being on or off.	Restricts accuracy of miss-distance calculations at missile endgame.
IV - 2.2.2 Surface-to-Surface Missiles (SSMs)	SSMs are modeled at a much lower level of fidelity than air-to-air and surface-to-air missiles. SSMs exist in Brawler to serve as targets. They are non-reactive, and their movement is based upon trajectory data read from predefined input data files.	Brawler by itself is not suitable for simulating SSMs with more complex behaviors. *Work is currently underway to add the ability to run in confederation with a higher fidelity SSM simulation, which will mitigate this limitation.*
IV-3. Sensors	Brawler assumes that the errors associated with successive observations of a single target are not correlated in time.	Affects uncertainty associated with sensor tracks, especially for sensors with large measurement errors. This can then affect pilot targeting and weapon firing decisions.
IV-3. Sensors	Brawler does not explicitly simulate false targets. Every sensor observation and every avionics track will correspond to some entity in the simulation. An observation or track may correspond to more than one entity if those entities cannot be individually resolved by the sensor making the observation.	Brawler assumes that the overall impact of the effect of false targets can be captured to first order by adjusting avionics performance parameters to delay, degrade, or deny target detections. If not, then a higher fidelity simulation is required.
IV-3. Sensors	Radar and visual detections are generally modeled strictly along Monte Carlo lines, with a probability of detection being computed and a random number drawn. However, if the existence of a target is known, the detection probabilities are enhanced, either explicitly or implicitly through better direction of the search process.	Negligible.

TABLE 3-2. Brawler Assumptions and Limitations, by Functional Element. (Contd.)

Functional Element	Assumption/Limitation	Impact Assessment
IV - 3. Sensors	Brawler has no explicit simulation of a head's up display (HUD), although the same attack steering information typically available through a HUD, such as min and max weapon ranges, allowable vs. actual steering error, etc., is available to the Brawler pilot model.	Model is not sensitive to differences between different HUD systems. *Work is under contract to simulate the enhancement of the pilot's ability to visually acquire targets based upon HUD cueing or the use of a helmet mounted sight.*
IV - 3. Sensors	Other than pilot eyeballs, Brawler does not simulate optical sensors.	Model is not suitable for use with scenarios involving optical sensors.
IV - 3. Sensors	Brawler does not simulate any acoustic signatures or sensors	Model is not suitable for use with scenarios involving acoustical detections.
IV - 3.1. Radar	Radar sidelobes are treated as constant gain for calculating sidelobe clutter and as a sin(x)/x pattern for calculating the signal of sidelobe noise jammers.	May over- or understate effects of sidelobe clutter or jamming if actual radar's sidelobes differ significantly from these assumptions.
IV-3.1.3 Radar Detection	The radar model assumes uniform ground reflectivity when calculating clutter statistics. Variations in target reflectivity can be captured by variations in the cross section data tables for the target. Brawler does not simulate multipath and diffraction effects.	Not sensitive to variations in ground reflectivity. As multipath and diffraction effects do not tend to be significant at altitudes above approximately 2000 feet, they are not expected to have a significant effect on most typical Brawler engagements.
IV-3.1.3 Radar Detection	Clutter is simulated at an effects level, taking into account the size, distance, and reflectivity of clutter patches.	Not generally significant. May affect results for engagements below 2000 ft.
IV - 3.1.4 Radar Tracking	Brawler allows a maximum of 120 tracks per radar.	Not significant, as this exceeds the total number of entities allowed in Brawler engagements.
IV-3.2 IRST Detection	The impact of IR clutter is treated statistically, assuming sensors perform spatial and/or temporal filtering. Atmospheric transmission is handled for each of several defined IR bands, with an implicit assumption of spectral uniformity within each band.	Not sensitive to variations in IR clutter with changes in location. May be important if actual sensor's detection bands do not match the bands defined for Brawler.
IV-3.2.3 IRST Detection	The IR signature model assumes that the time for engine and airframe hot parts to heat up or cool down in response to changes in engine state is short enough to ignore. Engine state does not, however, vary instantaneously with throttle setting. In other words, when a throttle setting changes, the engine spools up or down with a characteristic response time, and the IR signatures vary instantaneously as the state of the engine changes.	Not significant.

TABLE 3-2. Brawler Assumptions and Limitations, by Functional Element. (Contd.)

Functional Element	Assumption/Limitation	Impact Assessment
IV - 3.3.1 Missile Launch Warning Device Detections	The missile launch warning (MLW) device is an IR sensor that detects missiles in their burn phase. The MLW device does not perform detailed IR signature calculations, due to the general lack of IR signature data for missiles. Instead, it assumes that any missile within its detection range whose engine is burning will be detectable. The detection range can vary across the FOV of the device. Detection range as a function of azimuth and elevation is specified in the input data for the device.	Model is not sensitive to differences in IR signature between different missiles.
IV - 3.3.1 Missile Launch Warning Device Detections	MLW device is not affected by flares or the location of the sun.	Model is not sensitive to these effects.
IV - 3.4.1 Missile Approach Warning Device Cued Detections	Brawler assumes that the MAW device must be cued another avionics device, such as an RWR or missile launch warning device. Whether or not another device can cue an MAW is specified in the input data for the other device. If the device can cue the MAW, the cueing is automatically performed upon detection of a missile.	May not be adequate for simulating an autonomous MAW device.
IV - 3.4.1 Missile Approach Warning Device Cued Detections	The MAW device is not affected by countermeasures.	Generally not significant.
IV - 3.5.1 IFF/NCID Pilot Selection	Brawler assumes that pilots will only use Identification Friend-or-Foe and Noncooperative ID (IFF/NCID) devices to identify targets that they have already detected, as opposed to trying to use them to make initial detections.	IFF/NCID devices cannot produce initial detections.
IV - 3.6.1 RWR Detection	The RWR model assumes a constant emitter sidelobe out to ±120 degrees from the mainlobe centerline for AI and missile radars, and ±180 degrees for SAM and GCI/AWACS radars. This is illustrated below in Figure 3-1. The sidelobe angle is used to determine whether the RWR receives power from the radar's mainlobe, its sidelobe, or no power at all.	The assumption that the sidelobe is constant out to 120 or 180 degrees affects the calculation of the power incident on the RWR. Will not be accurate if sidelobes differ significantly from this assumption.

TABLE 3-2. Brawler Assumptions and Limitations, by Functional Element. (Contd.)

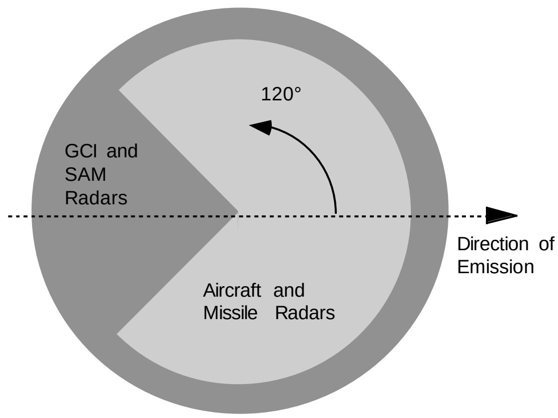
<table>
<tr><th>Functional Element</th><th>Assumption/Limitation</th><th>Impact Assessment</th></tr>
<tr><td colspan="3">

FIGURE 3-1. Radar Sidelobe Coverage.</td></tr>
<tr><td>IV - 3.8 Voice Comm.</td><td>Brawler assumes that when a radio channel is saturated due to jamming that all pilots on that channel will change to a new channel at the same time.
Brawler assumes that messages are either received completely or not at all. Partial or garbled messages are not simulated.</td><td>Model is not sensitive to effects of pilots being on wrong channels. Generally not a significant effect.

Model does not simulate extra comm. traffic due to requests for repeated messages. Generally not a significant effect.</td></tr>
<tr><td>IV - 3.9.2 Situation Awareness Networks</td><td>The Brawler sensor fusion device model integrates detections from designated contributing sensors into a common trackbank. A situation awareness network model is also provided. This permits the integration of sensor information from multiple platforms. Brawler assumes perfect correlation between observations shared between platforms.
The Brawler SFD uses the same establish/disestablish criteria for tracks of missiles as it uses for aircraft tracks.</td><td>Detailed information about which sensors are making observations may be lost when an SFD/SAN is used. This may affect weapon firing decisions.
See impact of perfect correlation, above.</td></tr>
<tr><td>IV - 4.1 Counter-measures</td><td>Various smart jammers are modeled at varying levels of fidelity.</td><td>Studies using low fidelity jammers on one side and high fidelity jammers on the other are subject to risk in interpretation of results.</td></tr>
<tr><td>IV - 4.1.1.2 Stand-off Jammers</td><td>Brawler assumes that stand-off jammer (SOJ) platforms are distant enough from an engagement that they will never be directly attacked.</td><td>Negligible. If an SOJ is close enough to be attacked, it should be implemented as a normal Brawler aircraft.</td></tr>
</table>

TABLE 3-2. Brawler Assumptions and Limitations, by Functional Element. (Contd.)

Functional Element	Assumption/Limitation	Impact Assessment
IV - 4.1.2 Expendables	The trajectory of expendables after they are launched is modeled explicitly, with the assumption that freely falling expendables will decay to a constant velocity downward trajectory. Brawler assumes that the effect of turbulence on the orientation of towed expendables is negligible. Brawler assumes that once the type of a missile has been determined, a pilot or avionics device that cues expendables will know the optimal time to impact at which to deploy the expendable.	Other trajectory types, such as self-propelled expendables, are not currently modeled. Generally not significant. May overstate expendable effectiveness.
IV - 4.1.2 Expendables	Expendables can be launched in multiple different directions and different launch velocities with respect to the body axes of the launching aircraft, but all expendable trajectories begin at the center of the aircraft.	Not significant unless expendables are launched from different points on a large airframe.
IV - 4.1.2.2 Chaff	Chaff position is explicitly simulated, but the blooming of a chaff cloud after deployment is not.	Restricts fidelity of chaff model to an effects level simulation.
IV - 4.1.2.3 Towed Decoys	The tow rope for towed decoys is assumed rigid. The time to deploy a towed decoy is assumed to be negligible.	Not generally significant. Can be mitigated by changing the time at which it is deployed.
IV - 4.1.3.2 RF Counter-measures	The Brawler decoy model uses a nominal RCS, maximum power, and lookup tables of transmitter and receiver gain vs. azimuth and elevation. Decoy model is not sensitive to signal polarization.	May require considerable effort to construct a data set.
IV - 4.1.3.2 RF Counter-measures	Terrain bounce ECM is not simulated.	Generally not significant for air-to-air engagements.
IV - 4.2 IR Counter-counter-measures (IRCCM)	IRCCM is not simulated in the Brawler missile model.	Model is not sensitive to the effects of IRCCM. *Work is under contract to provide this feature in future versions*.

On November 24, 1995, the error tracking system at DSA indicated that there were 19 software error reports awaiting analysis and/or final disposition. A summary of these is presented here.

TABLE 3-3. Known Errors, by Functional Element.

Functional Element	Error	Impact Assessment
I - 3.2 Statistics Reports	Weapon sector summary errors in MOPOUT file.	Affects report generation if weapons are aggregated by weapon name instead of by type (which is the usual method).
III - 1.2 Situation Assessment	Some off-boresight angles being computed w.r.t. velocity vector instead of body axes.	May be important in scenarios involving close-in combat with missiles capable of being fired in high off-boresight geometries.
III - 1.2.13 Missile Assessment	Missiles removed from BVR list too soon.	Only affects semi-active missiles that can be supported by radars in STT and TWS mode.
III - 1.3.4.5 Maneuver Decisions	Pure 1v1 maneuver not being generated correctly.	This alternative is not normally generated. Only affects scenarios where the generation of this alternative is enabled via a switch setting in the SCNRIO input file.
III - 1.3.4.6 Weapon Select Decision	Switchology delay too long in routine selwpn.	Applies to engagements where weapon selection can be changed in significantly less than 2 seconds.
III - 1.3.4.6 Weapon Select Decisions	Errors in decision logic w.r.t. high off-boresight shots.	Applies to scenarios using missiles that can be fired in high off-boresight geometries.
III - 1.3.5.5 Weapon Firing	Error in helmet mounted sight fire control test.	Affects scenarios where a helmet mounted sight is employed for seeker slaving.
IV - 2.1.1.1 Seekers	Local variable no_obs set wrong in skob_arm	Error in diagnostic print. No effect on simulation results.
IV - 2.1.1.1 Seekers	Missiles being fired with wrong seeker locked.	Applies to multiple-seeker missiles that can be fired with one of several seekers locked at launch.
IV - 2.1.1.2 Guidance	Missiles with non-zero gyro misalignment not guiding properly.	Applies to missiles with non-zero values for gyro drift and misalignment. These values are zero for most Brawler data sets.
IV - 2.2.2 Surface-to-Surface Missiles	Surface-to-surface missile flyout testing on range instead of velocity.	Only affects SSMs whose descending trajectory becomes exactly vertical.
IV - 3. Sensors	ITBAD being applied to SSMs.	Applies to scenarios where SSMs are detected at altitudes above 100,000 ft.
IV - 3.1.1 Gimbal Radars	Abort in adjrdr, LOS to target is zero vector.	Only affects scenarios that begin within radar detection range and involve TWS radars that establish tracks within the first second of the simulation.
IV - 3.1.2 ESA Radars	Power per look not used correctly in Pd calculation for ESA radars.	Affects scenarios where ESA radars are employed and where radar power varies.

TABLE 3-3. Known Errors, by Functional Element.

Functional Element	Error	Impact Assessment
IV - 3.7.2 Visual Detection	Visual detection of missiles not sensitive to day/night.	Applies to night scenarios involving combat within visual range.
IV - 3.9.4 Integrated Trackbank	No time based purge criterion for integrated track bank.	Affects scenarios employing sensor fusion devices in situations where updates may be infrequent.
IV - 4.1.2 Expendables	Expendables cued using ground truth missile seeker state.	Affects scenarios employing multiple seeker missiles and expendables that are effective against them.
IV - 4.1.3.1.2 Pk Degrade	Abort when using Pk degrade expendable.	Only occurs if missile has no track to guide on, then observes expendable and nothing else.
IV - 4.1.3.2 RF Counter-measures Techniques	Bug in ECCM portion of sjrrgp	Affects scenarios involving gate-pulloff jammers where there is a non-zero possibility of eccm guard gate being effective.

3.1 TRACKING OF ERRORS AND ANOMALIES

Figure 3-2 presents a 2 1/2-year record of the number of errors reported in Brawler software or documentation. It is divided into errors uncovered at DSA in the course of testing and errors reported from elsewhere, either by beta-site testers or by model users.

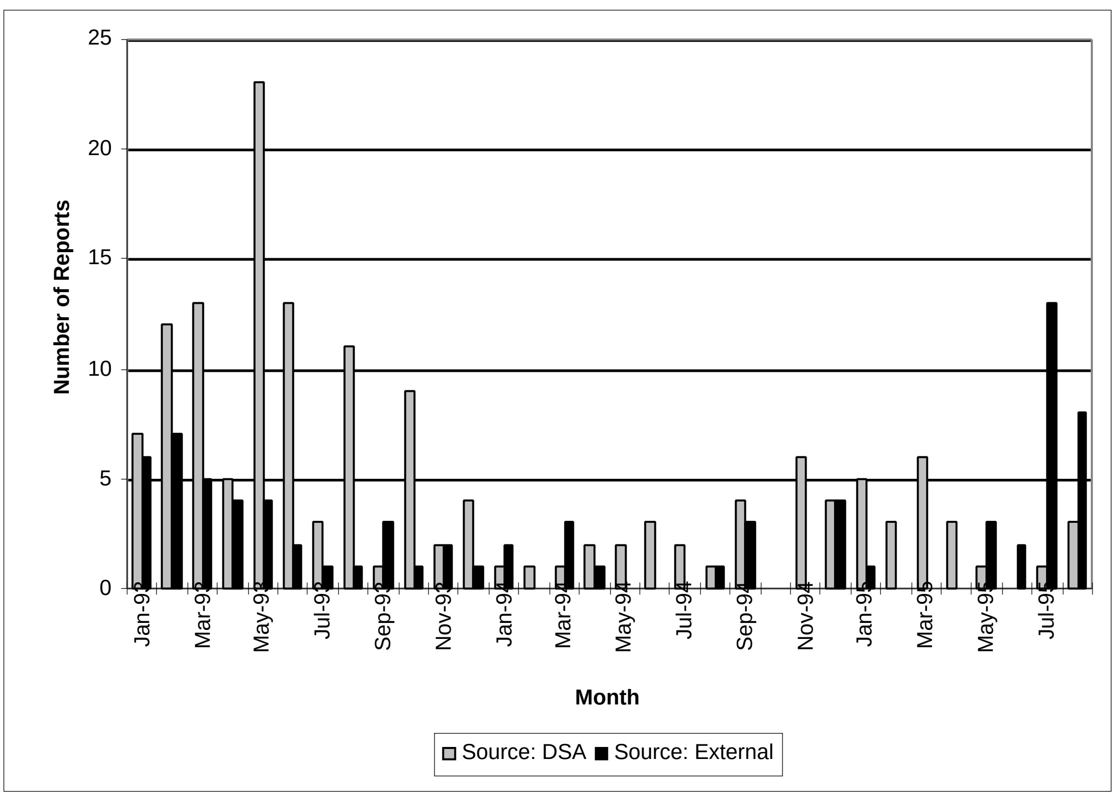


FIGURE 3-2. Software Error Report History.

Significant fluctuations in the numbers of errors reported correspond to the release cycle of new versions of Brawler. Version V6.15 was frozen at DSA at the end of May, 1993, and underwent in-house testing until its release to the user community in late October, 1993. Version V6.2 was frozen at DSA at the end of August, 1994, and began testing at DSA. Full-time beta-site testing at AFSAA began in July of 1995, which accounts for the increase in externally reported errors at that time.

3.2 IMPLICATIONS FOR MODEL USE

The assumptions, limitations, and errors listed above all have varying effects on an assessment of the applicability of the model. In each case, one must consider the ALE list in the context of the scenarios to be used in the study. For example, a study of air-to-air engagements in a region with a high density of SAM sites using Brawler might be considered deficient due to the low fidelity of SAM site modeling. Other known scenarios which might not be captured adequately in Brawler include those in regions with frequent severe weather or high cloud densities, low altitude scenarios in regions of rugged terrain, or scenarios in which significant off-board (satellites, etc.) assets are expected to play a significant role. In addition, the fact that different countermeasures techniques are simulated in Brawler with different effects models, and that the level of fidelity of these effects models is not the same for all techniques, will limit the applicability of Brawler in scenarios that involve a mix of ECM techniques that are simulated at different levels of fidelity.

The implications of the list of errors on model usage deserves special attention. There are actually several categories of errors on such a list. Some errors have no effect on combat outcomes (errors in utilities, for example). In addition, since many errors on the list are reported by users, some of those errors are ultimately determined to be user errors; perhaps a misinterpretation of output, an invalid input value, or poorly written production rules. Such errors remain on the list until they are either resolved or it is judged that the user’s error cannot be reproduced. Hence it is risky to make claims about the implications of an error report until such time as the error can be confirmed. Finally, even if the source of an error is determined, it may be difficult to ascertain under what circumstances that error will have an effect on study results. In fact, that determination itself could warrant a study.

To sum up, the assumptions, limitations, and known errors in Brawler should always be reviewed to assess their implications for a proposed study. This is particularly important if the study scenario is subject to the effects of weather, terrain, or multiple countermeasures.